公立大学法人 横浜市立大学
YOKOHAMA CITY UNIVERSITY

Ruggero Micheletto

Ph.D. in physics, Professor

Yokohama City University

mail ： ruggero@yokohama-cu.ac.jp

14 of February, 2013

Ruggero Micheletto

Physics Degree
(De Marco, Violino)

Physics PhD
(Turchetti)

Kanagawa Academy of Science（Ohtsu）
Riken（Knoll, Hara）

Yokohama City University
Full professor (2008～)

Kyoto University, Anal.Chem. assistant professor
Kyoto University, Elect. Science（project leader）

Ruggero Micheletto 家内

Ruggero Micheletto 家族

[Patologia chirurgica veterinaria e podologia](books.google.co.jp/books?isbn=8802035563)

books.google.co.jp/books?isbn=8802035563

Bruno Micheletto - 1980 - プレビューは利用できません

[Fisiopatologia e clinica delle articolazioni degli animali ...](books.google.co.jp/books?id=iLpCcgAACAAJ)

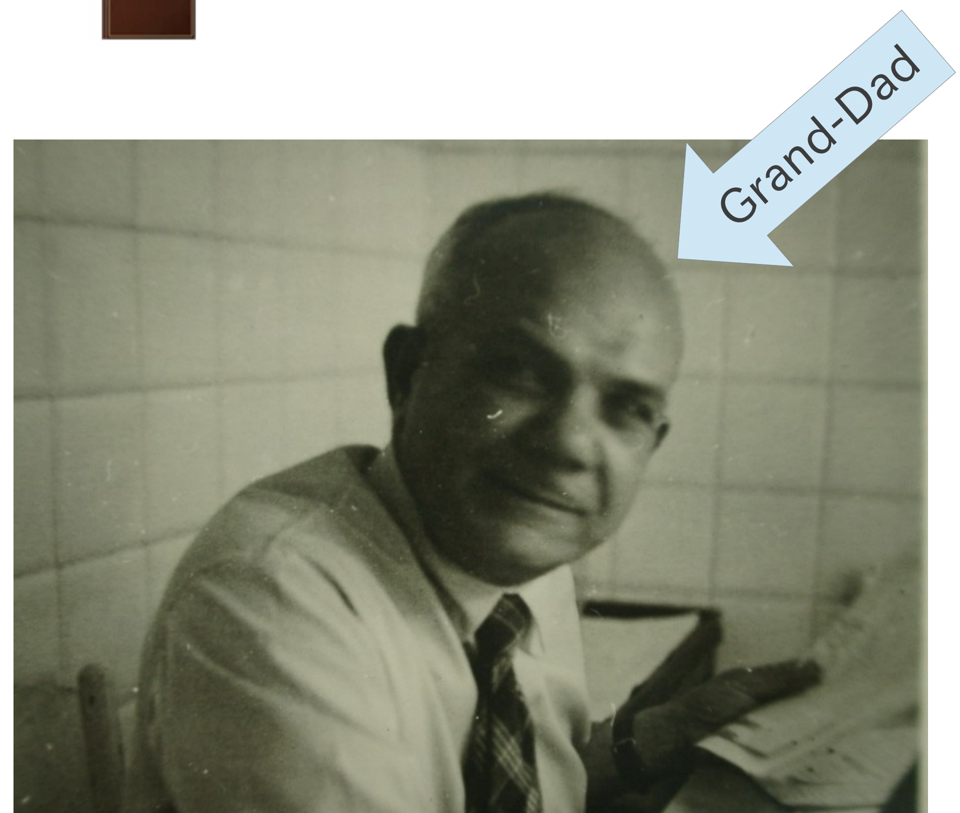
books.google.co.jp/books?id=iLpCcgAACAAJ

Bruno Micheletto, Pietro Sartoris, Società italiana delle scienze veterinarie. Convegno - 1963 - プレビューは利用できません

[Semeiotica chirurgica veterinaria](books.google.co.jp/books?isbn=8820619415)

books.google.co.jp/books?isbn=8820619415

Bruno Micheletto, Mario Fedrigo - 1983 - プレビューは利用できません




Cousin


Cousins
Cousin
Son


Me


daughter

YOKOHAMA
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京都大学

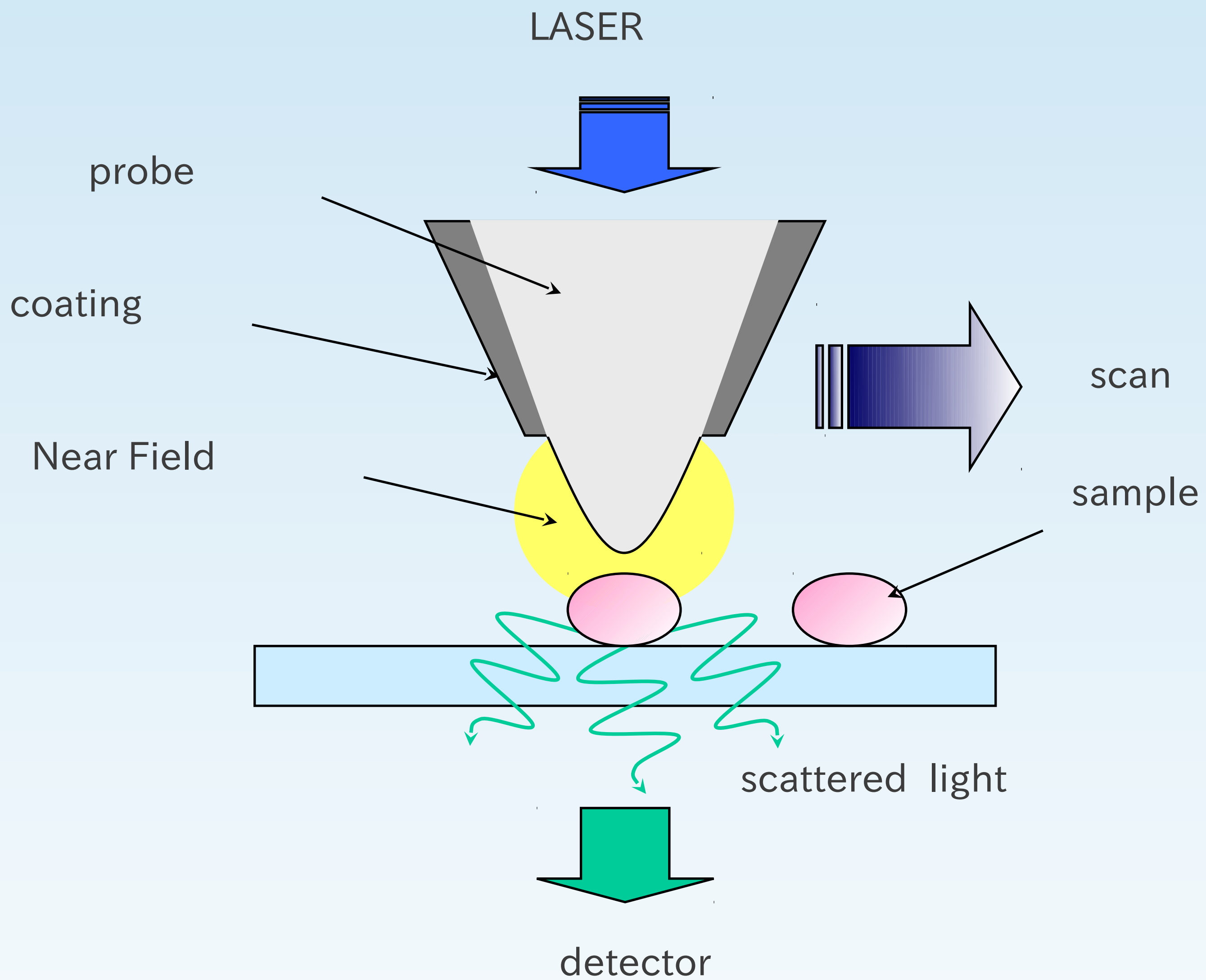
Ruggero Micheletto,

Past research activities:

Optical near-field studies

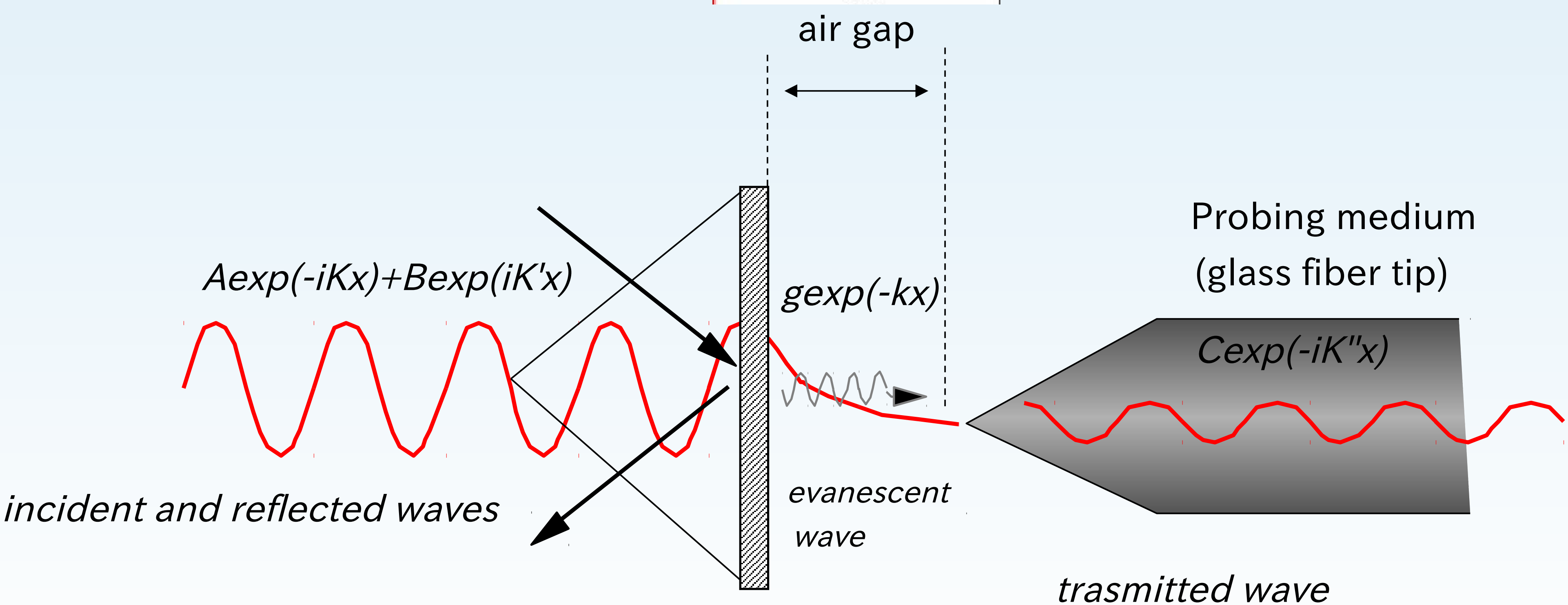
mail：ruggero@yokohama-cu.ac.jp

14 of February, 2013

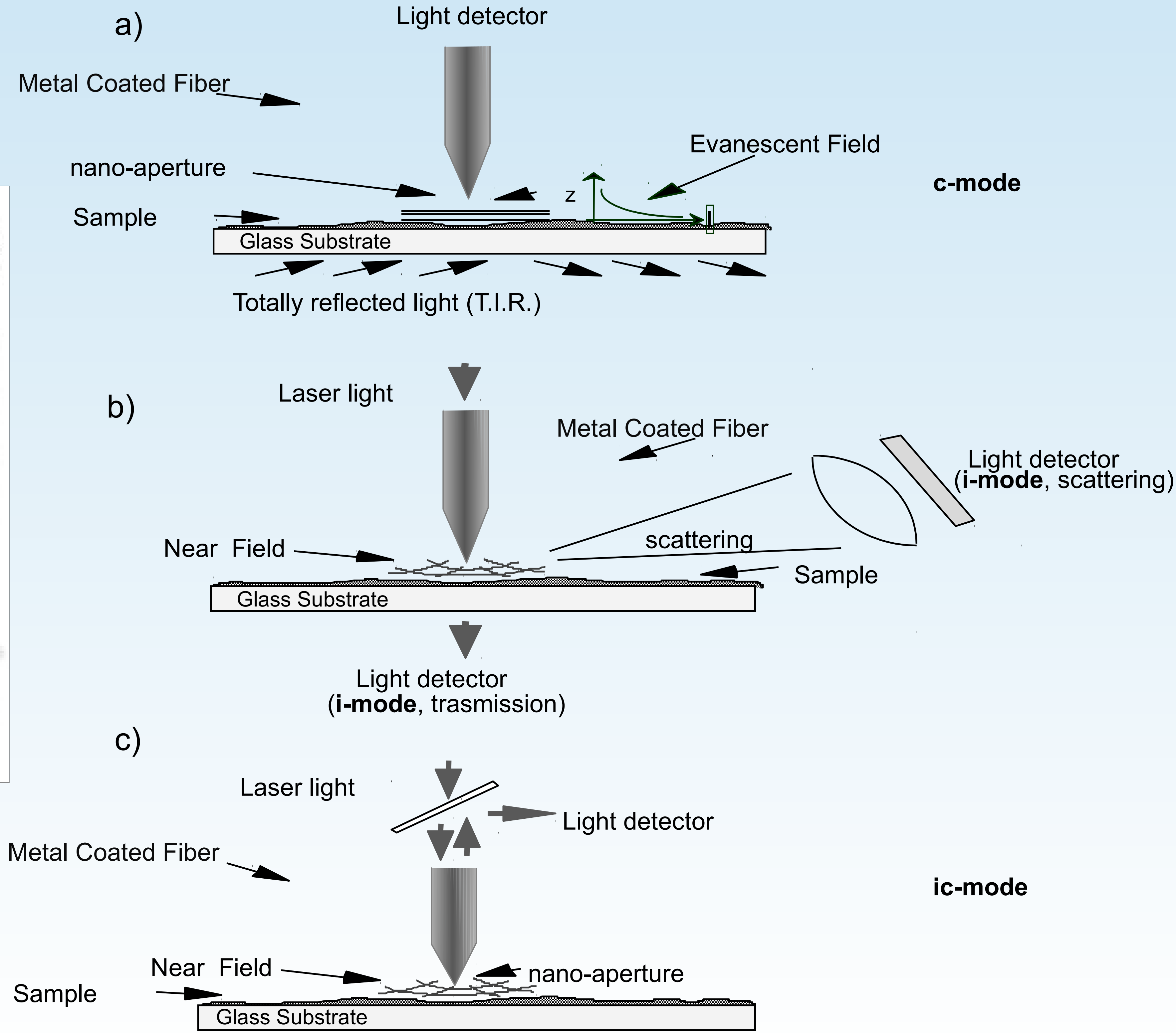

LASER
probe
coating
Near Field
scan
sample
scattered light
detector

The signal measured is Exponentially dependent to the morphology in “Z”

The intensity is function of the gap distance



京都大学


a)
Light detector
Metal Coated Fiber
nano-aperture
Sample
Evanescent Field
z
Glass Substrate
Totally reflected light (T.I.R.)
c-mode
b)
Laser light
Metal Coated Fiber
Light detector
(**i-mode**, scattering)
Near Field
scattering
Sample
Glass Substrate
Light detector
(**i-mode**, trasmission)
c)
Laser light
Light detector
Metal Coated Fiber
ic-mode
Near Field
nano-aperture
Sample
Glass Substrate

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京都大学

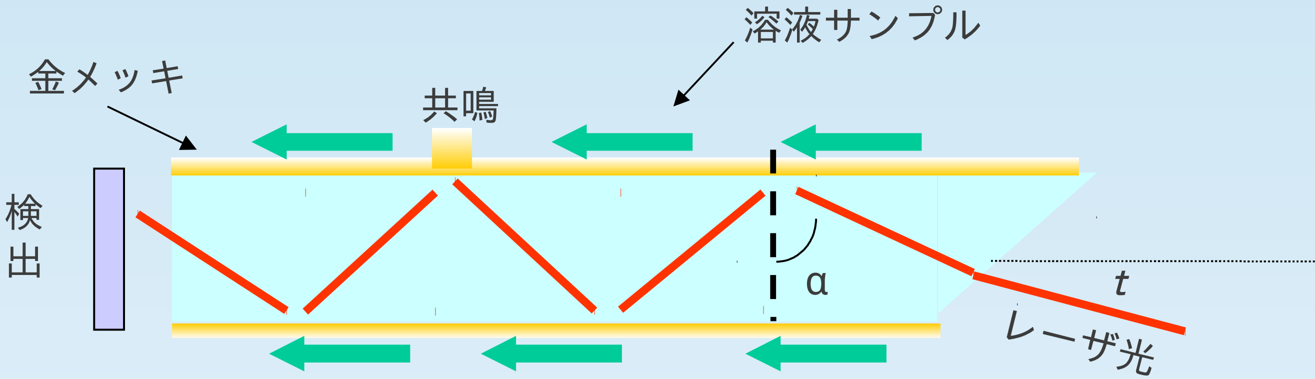
Ruggero Micheletto,

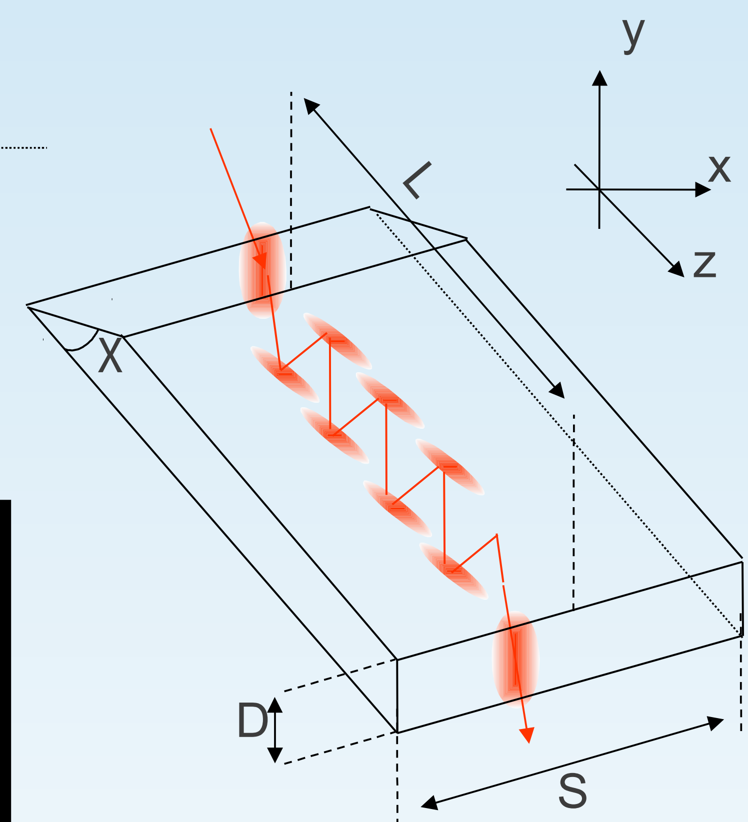
Research activities:

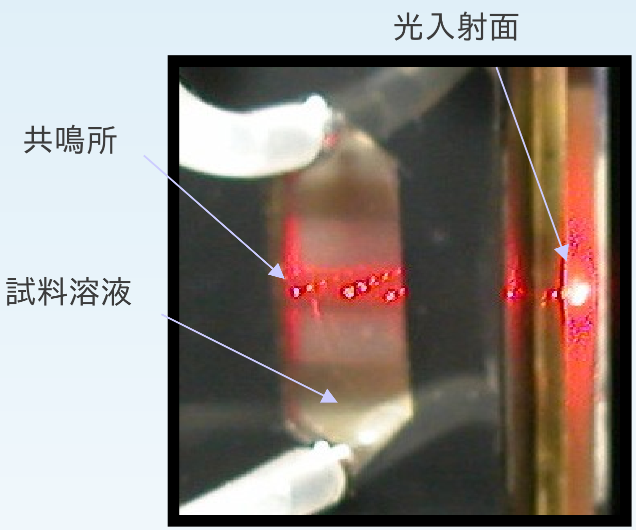
<u>Critical angle studies</u>

mail ： ruggero@yokohama-cu.ac.jp

14 of February, 2013

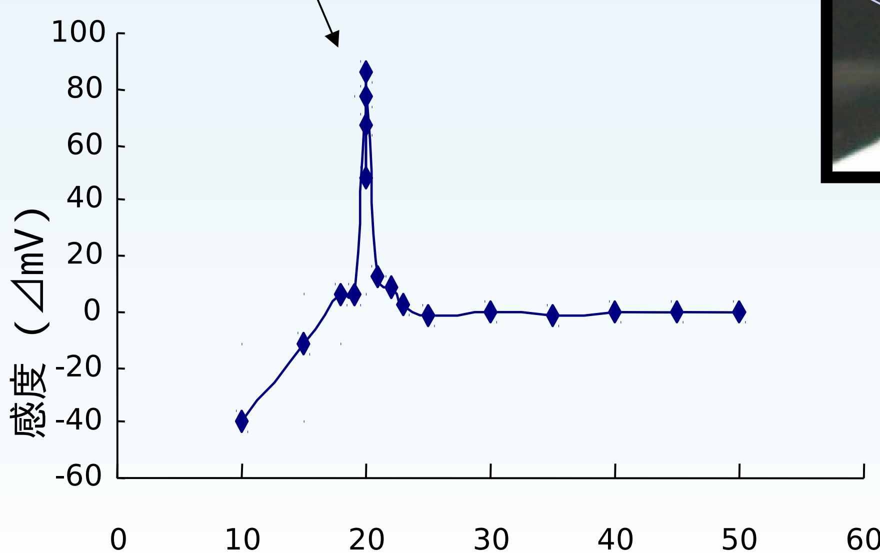

溶液サンプル
金メッキ
共鳴
検出
α
t
レーザ光


y
x
z
L
X
D
S


光入射面
共鳴所
試料溶液

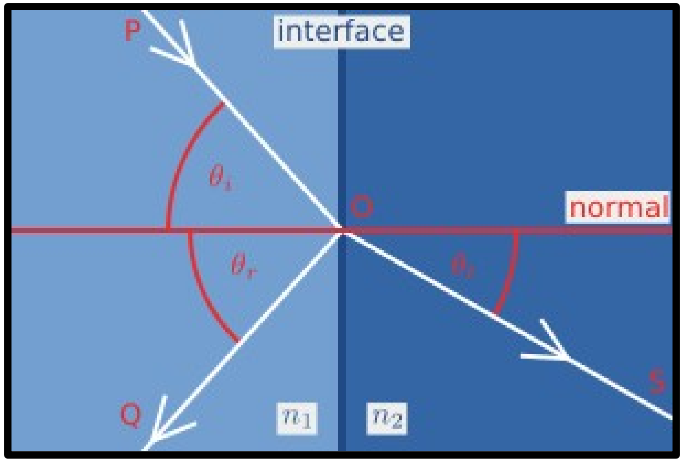
濱本さん開発

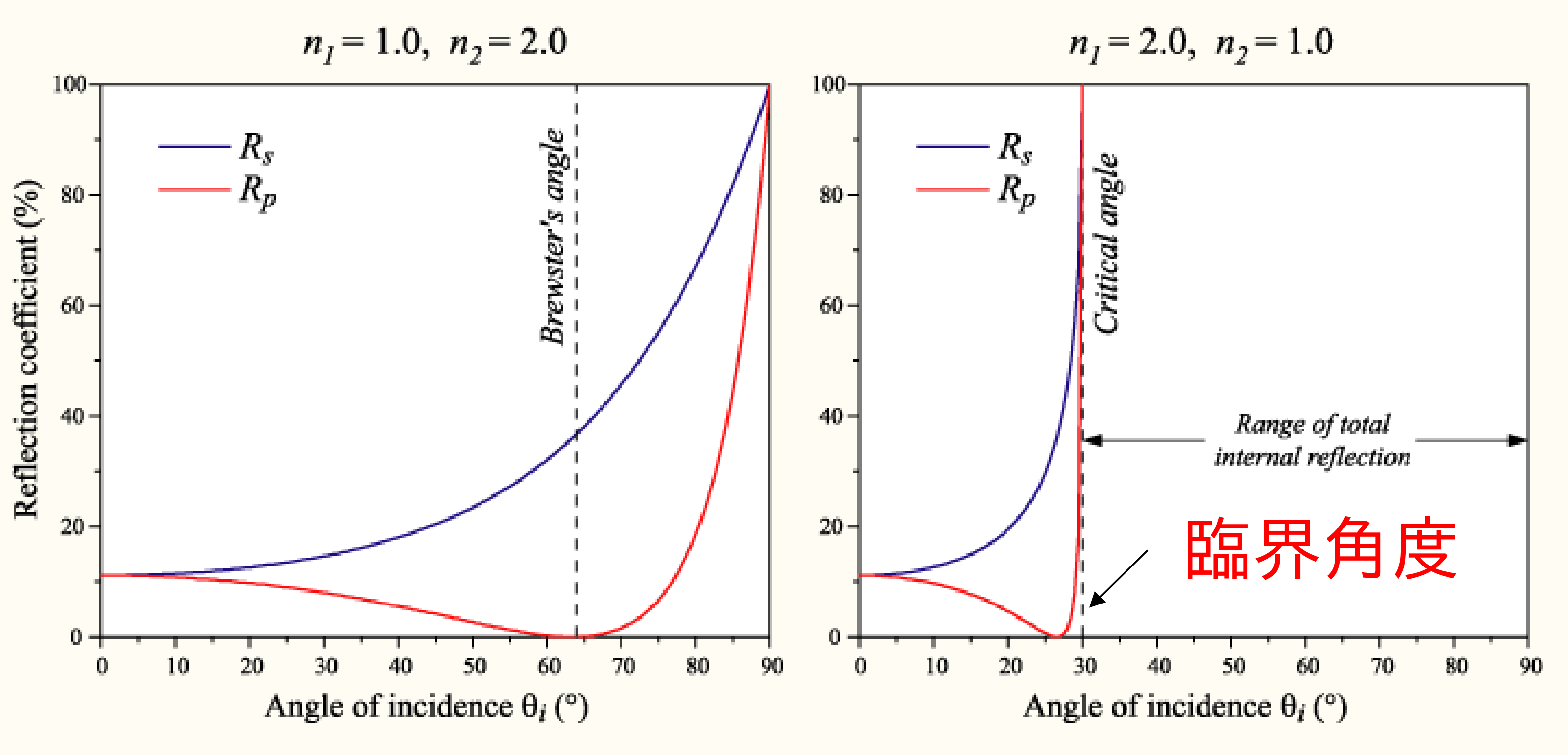
臨界角度


感度（⊿mV）
100
80
60
40
20
0
-20
-40
-60
0
10
20
30
40
50
60

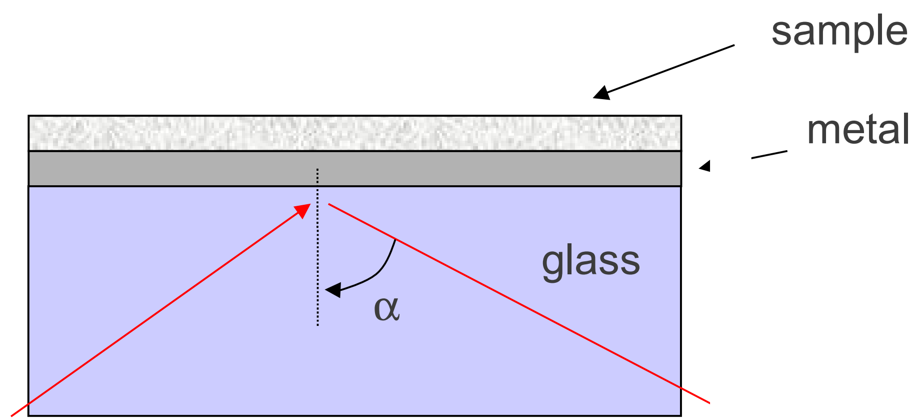
反射率の法則

角度の振る舞い:SNELL法則
反射率(強度):FRESNEL法則





Fresnel Equations for a three-layers complex system



$$R=\left|\frac{r_{pm}+r_{ms}e^{2ik_{mz}d}}{1+r_{pm}r_{ms}e^{2ik_{mz}d}}\right|^2$$

$$r_{pm}=\frac{k_{pz}\varepsilon_m-k_{mz}\varepsilon_p}{k_{pz}\varepsilon_m+k_{mz}\varepsilon_p}$$

$$r_{ms}=\frac{k_{mz}\varepsilon_s-k_{sz}\varepsilon_m}{k_{mz}\varepsilon_s+k_{sz}\varepsilon_m}$$

$$k_{jz}=\sqrt{\varepsilon_j\frac{\omega^2}{c^2}}]^{j}\quad{,m,s}$$

$$k_x=\sqrt{\varepsilon_p}\frac{\omega}{c}\sin\alpha$$

$$\varepsilon_m=\varepsilon_{m^\infty}-\frac{\omega_p^2}{\omega(\omega+i\omega_\tau)}$$

glass

$\varepsilon_p=1.52$

sample

$\varepsilon_s=1.00$

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プラズモン共鳴の多重反射を利用する

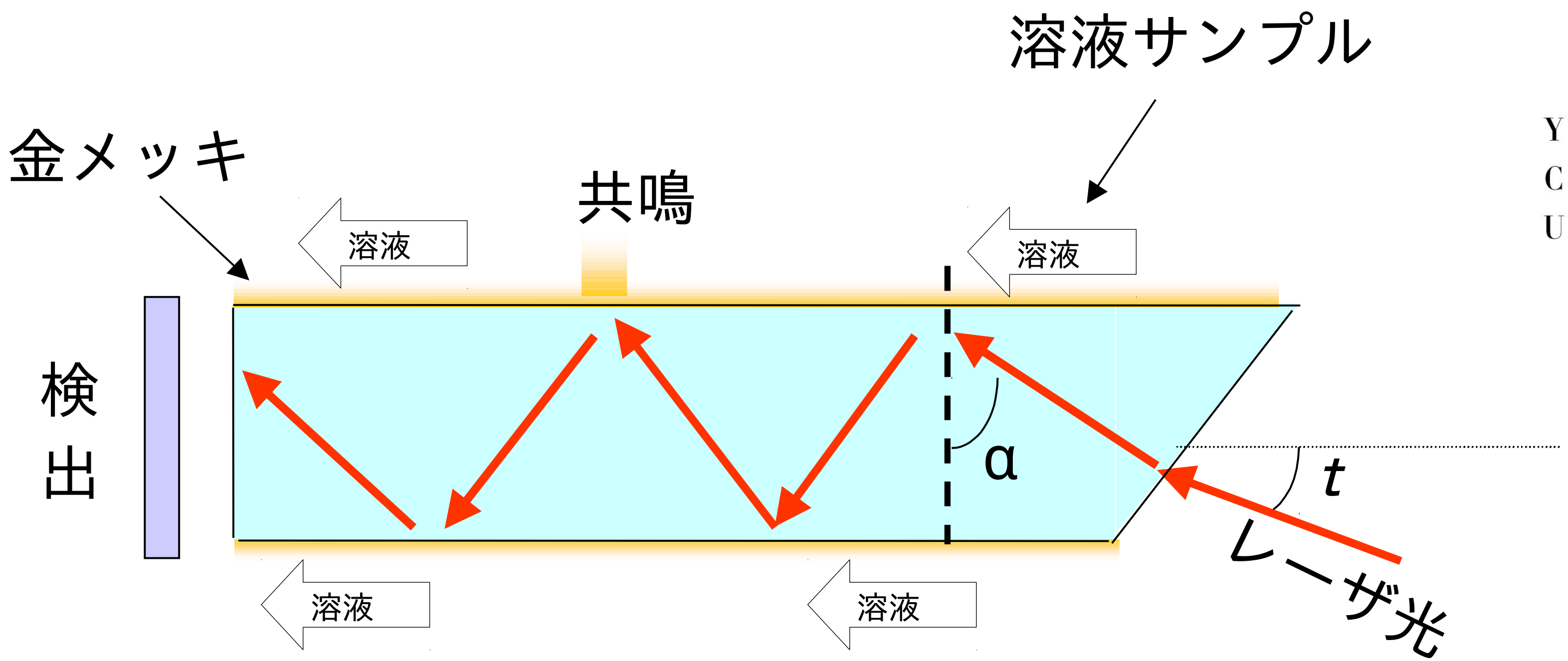
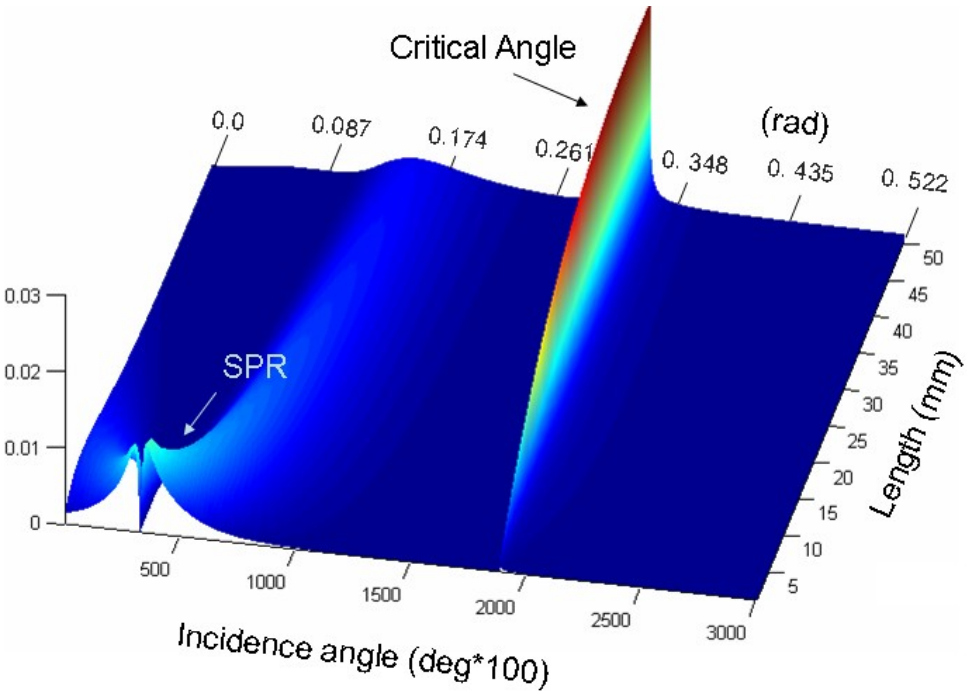


図1．ＳＰＲシステムの中心の基本的な図面　　　金でメッキされたグラスにプラズモン共鳴が何度も起こります　　　。



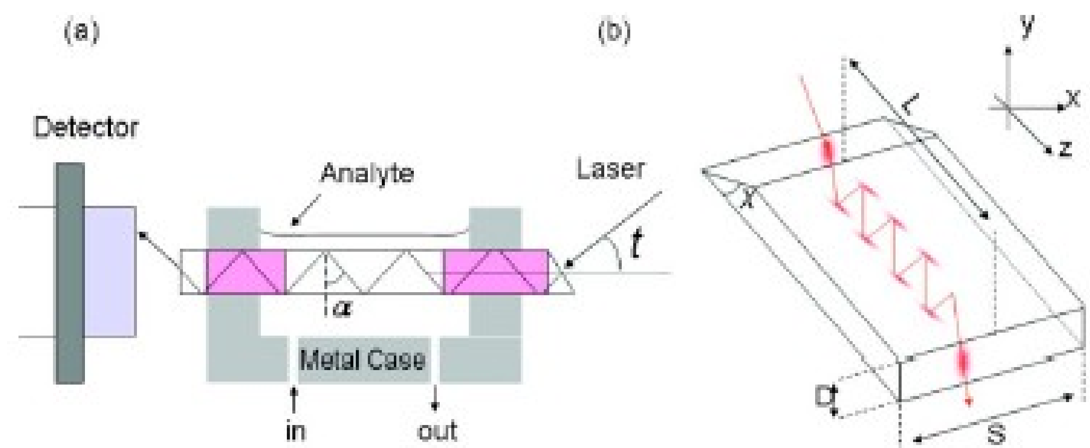
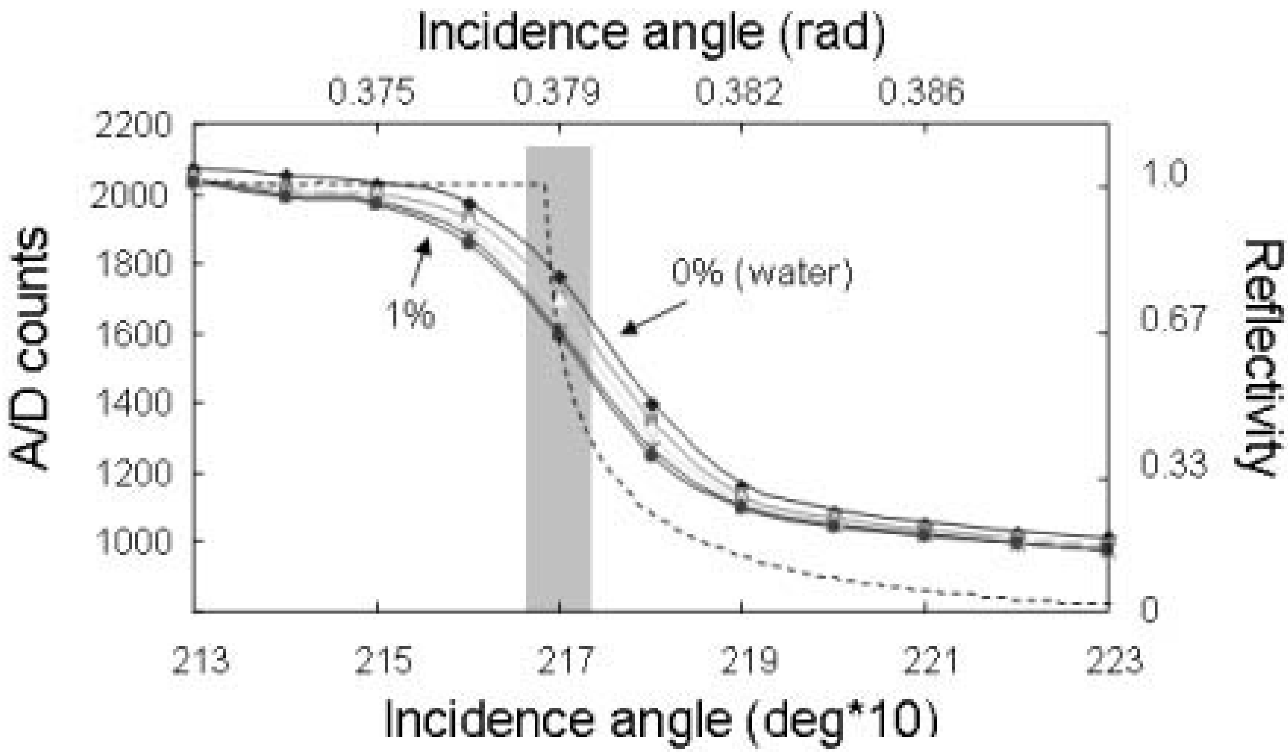


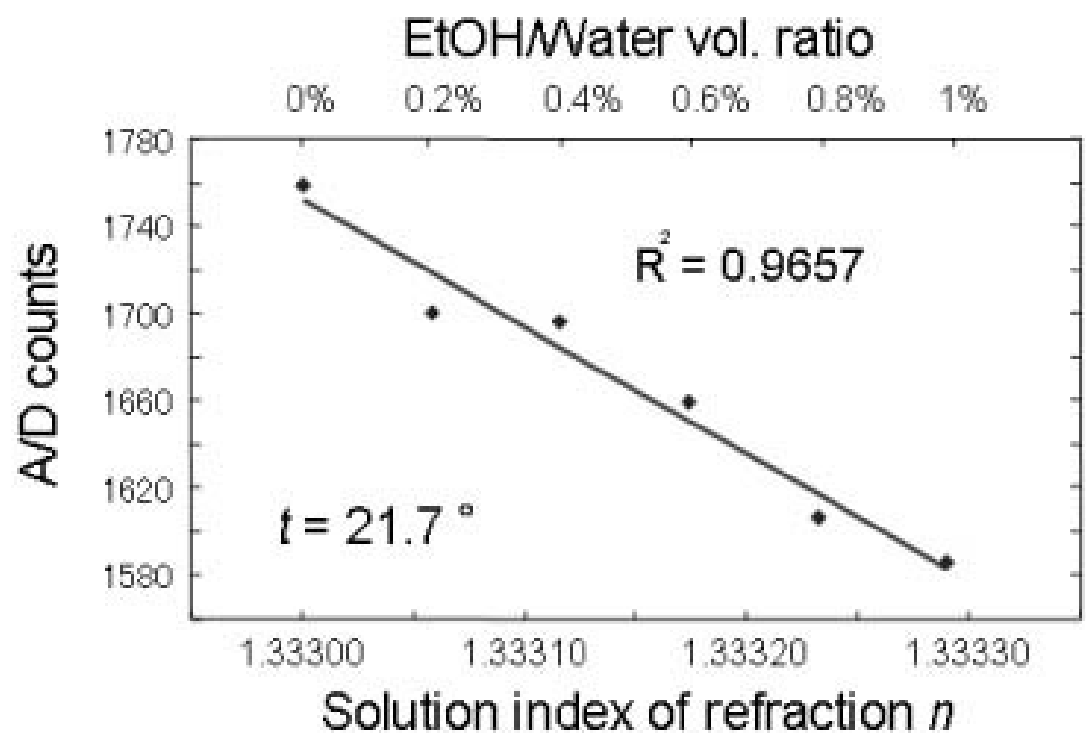
Fig. 3. (Color online) Core of the test device. (a) Planar glass is immersed in a flow cell with the analyte liquid. Light is applied at incidence angle t from a $\chi=45°$ surface. (b) Three-dimensional sketch of the planar glass.



$$\frac{dn}{dC}=0.0003/173$$

$$\delta \simeq 10^{-6}$$

ベストin the worldと同じ



2004年(平成16年)4月1日　木曜日

低価格、高感度のセンサー

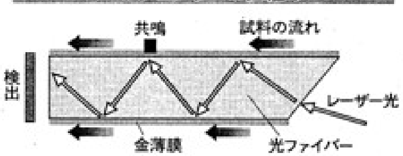
がん診断・汚染物質検出に威力

知的クラスター成果

京都ナノテククラスターのルジェロ・ミケレット研究員と臨床検査機器などを手掛けるテラメックス（京都市伏見区）は、表面プラズモン共鳴（SPR）と呼ばれる光学現象を利用して高感度で安価なバイオセンサーを製造する技術を開発した。従来のSPRセンサーに比べて価格が約十分の一で済み、がんの早期診断や環境汚染物質の検出などに威力を発揮する。

ミケレット研究員らが開発したSPRバイオセンサー（京都市西京区・京都大桂キャンパス）

バイオセンサーの仕組み



SPRは、底面に金属薄膜を張り付けたプリズムに特定の角度から光を当てると、薄膜表面の自由電子と光が共鳴し、光が吸収される現象。薄膜に抗体を結合させておき、抗原を含んだ試料を薄膜表面に流すと、抗体と抗原が結合した際に反射光の屈折率が変化する。

表面プラズモン共鳴を利用　来年実用化へ

この現象を利用すれば、血液中のがん因子の有無や水中の環境汚染物質の存在などが確認できる。次世代のバイオセンサーとして期待されてきたが、プリズムに金属薄膜をつける工程に手間がかかったり、入射光の角度を制御するのに周辺装置を必要とするなどのデメリットがあった。

ミケレット研究員らは、光学部品を光ファイバーで代用した。光ファイバーの周囲に厚さ約五十ナノ（十億分の一）㍍の金の薄膜を張り付け、検出したい抗原に対応する抗体を表面に結合。薄膜表面に試料を流し、光ファイバーの断面から光を入れると、内部で多重反射し、薄膜の複数個所でSPRが起こる。

光ファイバーから出る光の強度を計測し試料を流していないときと比べれば、抗原の結合が把握できる。

複数個所でSPRを起こせるため、感度がプリズム方式の三十—五十倍に向上。多重反射であれば、入射角を細かく制御しなくてもSPRを起こしやすいため、光源を位置制御する装置が不要になった。市販品を用いるので部品は使い捨てでき、従来のSPRセンサーの十分の一となる数百万円前後で実用化できる。

産学連携を支援する文部科学省の知的クラスター事業の成果。

今後、装置をコンパクトにするなど改良を加え、来年にも実用化する。

改善し、サービス業はプラスに転じる見通し。

IYバンクと

なる。手数料や利用時間などの詳細は未定。

R. Micheletto, K. Hamamoto, S. Kawai and Y. Kawakami, "Index of Refraction sensors: virtually unlimited sensing power at critical angle", Optics Letters, **31**, 2, 205-207 (2006)

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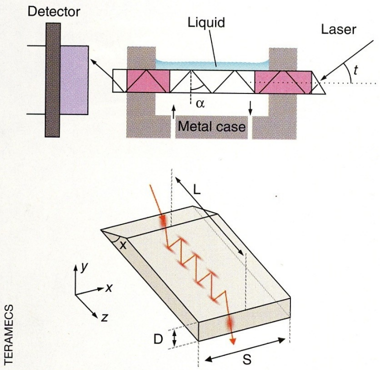


In the refractive-index sensor, planar glass is immersed in a flow cell with the liquid to be analyzed (top). A 3-D sketch of the planar glass (bottom) shows how light is applied at an angle t to its χ = 45° surface.

ing. Light from a HeNe laser at 670 nm is input at variable angles to the 45° bevel on one end of the slide, onto which an analyte is flowed (see figure). This configuration generates multiple internal reflections, amplifying the discontinuity in the critical angle. To test the sensitivity of the device, six concentrations of ethanol from 0% to 1% in water were used as the analyte. For this experiment, an uncoated slide was used, meaning that SPR is not involved in the measurement. Analysis produced a refractive-index sensitivity on the order of 10^{-6}—better than SPR sensors, and close to the best sensitivity ever recorded. Improvements in beam divergence, focusing, detector sensitivity, and A/D converter resolution could further improve the sensitivity values.

Researcher Ruggero Micheletto became interested years ago in the tiny discontinuity that appeared to the left of the SPR peak—originally, deemed "unimportant" by colleagues. But eventually, he made rigorous but basic calculations that demonstrated the presence of an actual infinite discontinuity in that point, and working with Teramecs, realized a first prototype. "We believe that critical-angle systems can be used to realize extremely sensitive devices for specific molecules," adds Micheletto. "Though the sharpness of the discontinuity precludes us from detecting a wide range of samples simultaneously, it is foreseeable to realize dedicated sensors for specific molecules with ultra-high sensitivity. We envision new gas sensors, pollution sensors for liquids, environmental sensors, or even temperature sensors (temperature alters the index of refraction)."

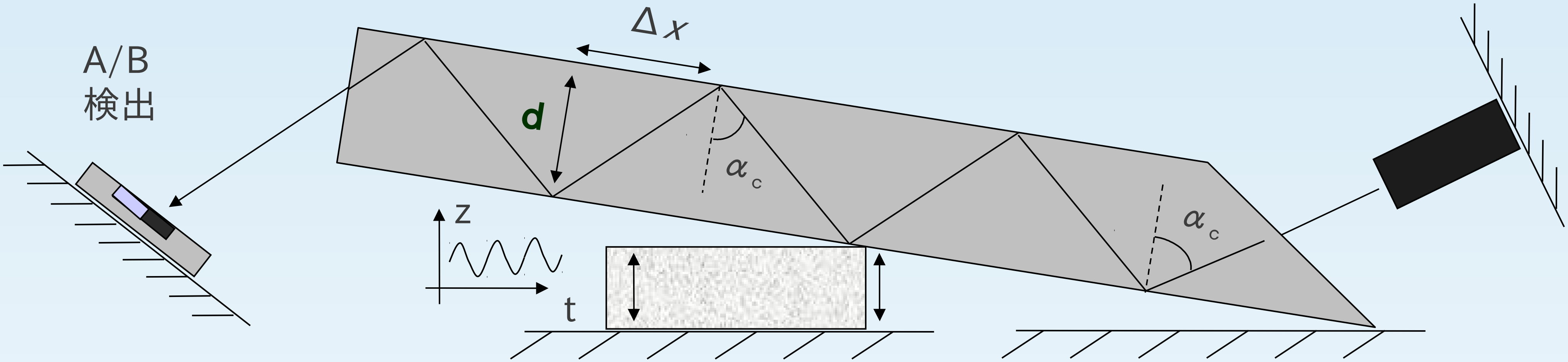
Gail Overton

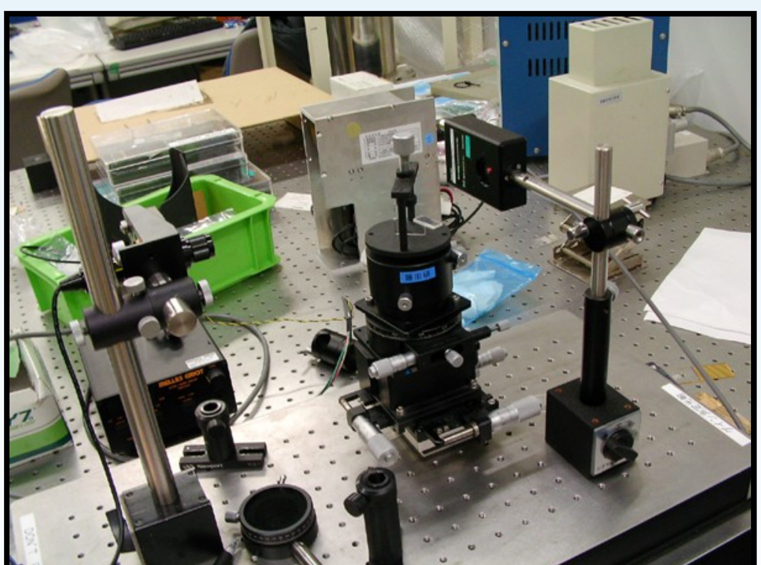
REFERENCE

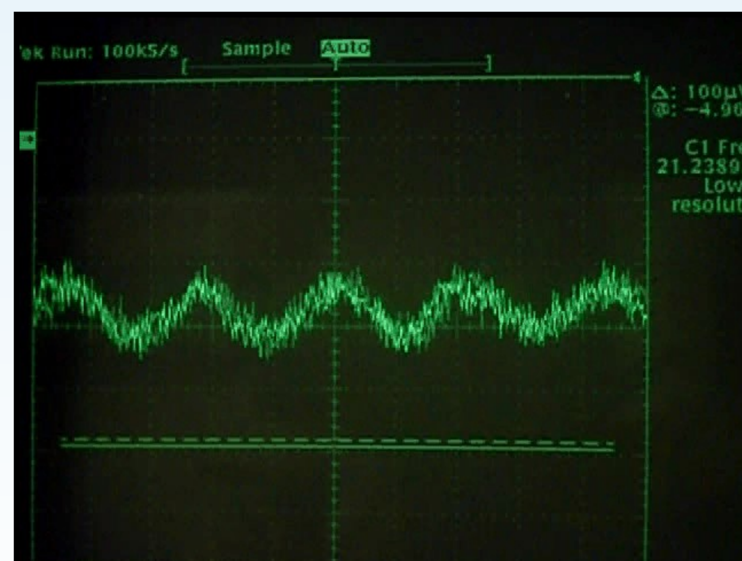
1. R. Micheletto et al., *Optics Letters 30*(2) 205 (Jan. 15, 2006).

A multiple reflection passive amplification vibration sensor

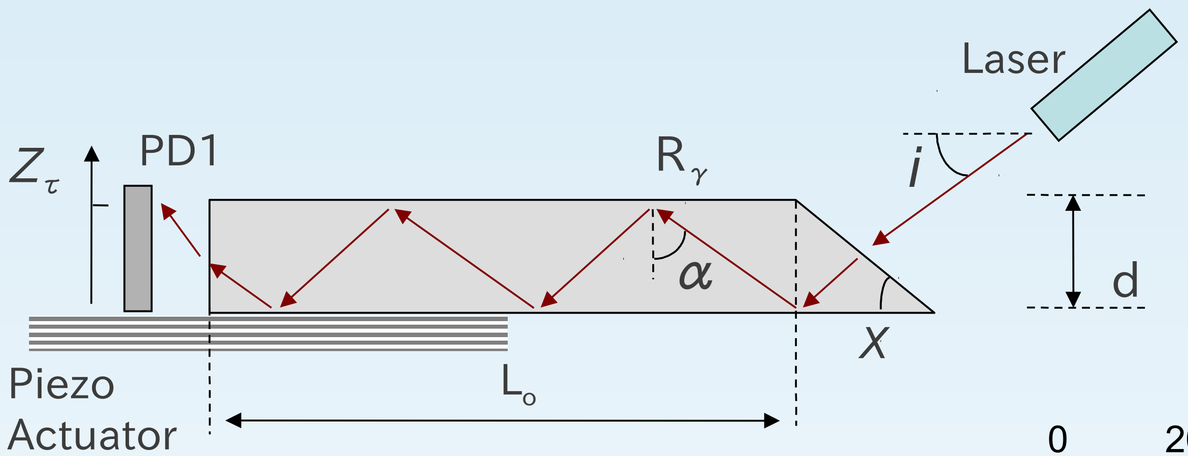
$S_{信号}=S_a-S_b$



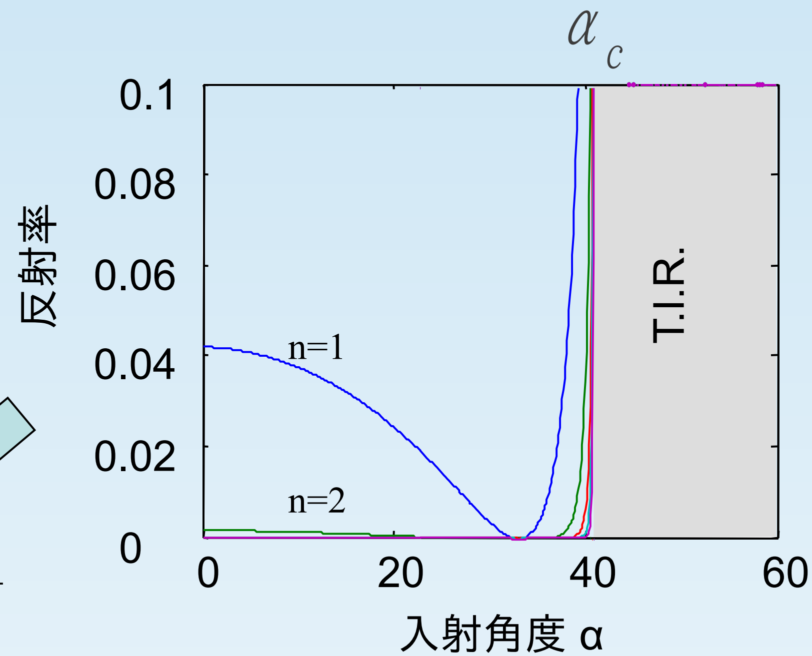




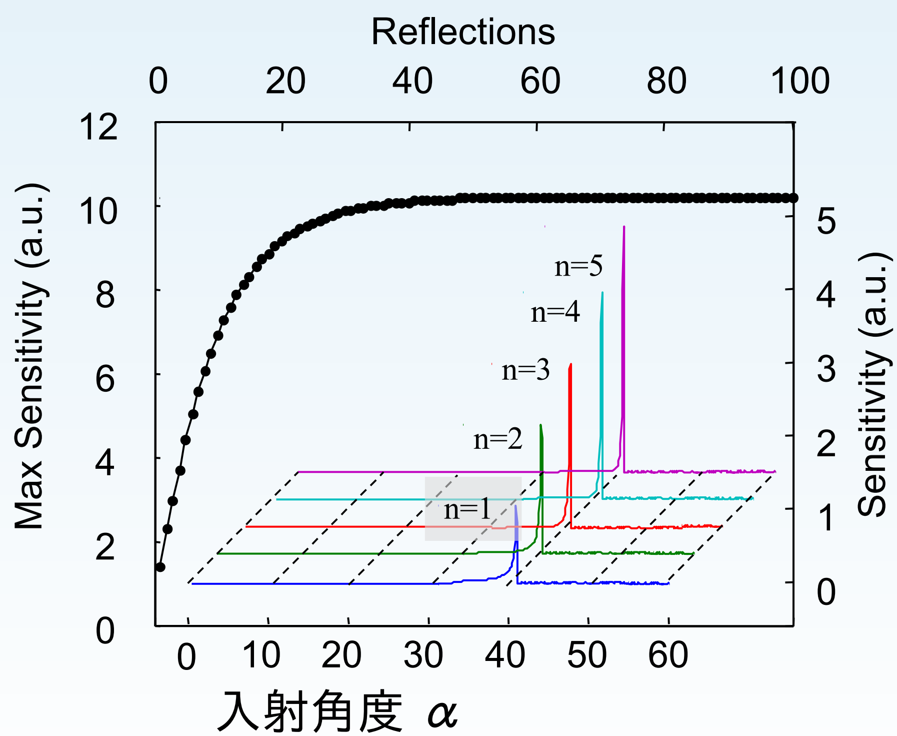
超高感度振動センサー



Laser
PD1
Z_τ
R_γ
i
α
d
X
Piezo
Actuator
L_o



α_c
反射率
0.1
0.08
0.06
0.04
0.02
0
n=1
n=2
T.I.R.
0
20
40
60
入射角度 α



Reflections
0
20
40
60
80
100
Max Sensitivity (a.u.)
12
10
8
6
4
2
0
n=5
n=4
n=3
n=2
n=1
Sensitivity (a.u.)
5
4
3
2
1
0
0
10
20
30
40
50
60
入射角度 α

APPLIED PHYSICS LETTERS **90**, 244108 (2007)

Optical nanometer-scale sensing of mechanical vibrations with a planar glass at critical angle

Ruggero Micheletto[a)] and Yoichi Kawakami
Graduate School of Engineering, Department of Electronic Science, Kyoto University, Nishigyo-ku, Katsura, 615-8510 Kyoto, Japan

Katsumi Hamamoto
Teramecs Ltd., 97 Higashi Koyanouchi-cho, Takeda, Fushimi-ku, 612-8448 Kyoto, Japan

(Received 30 October 2006; accepted 16 May 2007; published online 15 June 2007)

The authors have devised an optical multireflection system to detect nanometer-scale mechanical vibrations in a very simple and cost effective manner. The system is based on a planar glass, reflecting laser light internally a number of times in near critical angular conditions. Any small angular displacement results in an abrupt change of reflectivity. Monitoring the light at the exit of the device results in extremely high sensitivity to small mechanical vibrations. Calibrated tiny vibrations of 2.4 nm were resolved corresponding to an angular shift of about 2×10^{-7} rad.
© *2007 American Institute of Physics.* [DOI: 10.1063/1.2747676]

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The development of a super high sensitivity **shadow sensor** for Gravitational Waves detection

R. Micheletto

K. Kuroda, R. De Salvo, W. Chonmeng, T. Akutsu

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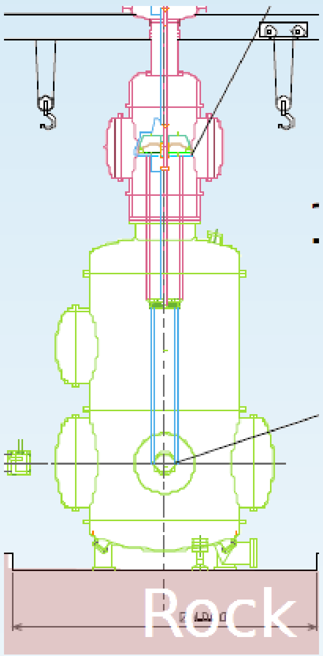
14 of February, 2013

The Remote Shadow Sensor

RSS

The goal of this research is to realize a super-high sensitivity “remote shadow sensor” (RSS) for the future KAGRA seismic waves detector.



Rod monitoring

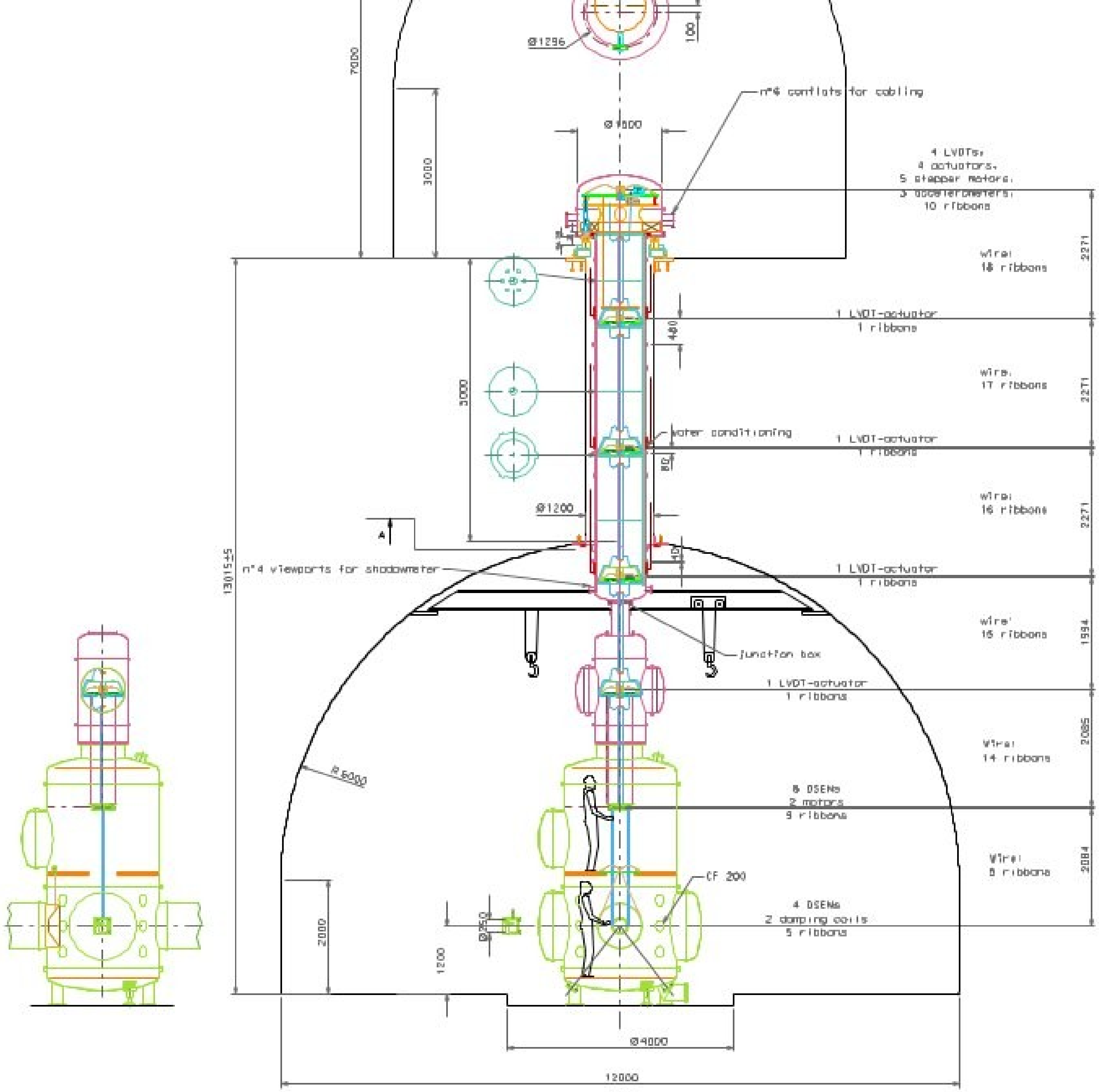
This sensor will monitor **optically** the position one of the rod that holds the main mirrors of the KAGRA system.

Consolidate KAGRA data

RSS will be able to detect **fraction of nanometer displacements** of the rods. It an auxiliary sensor very important to consolidate the data collection acquired in KAGRA.

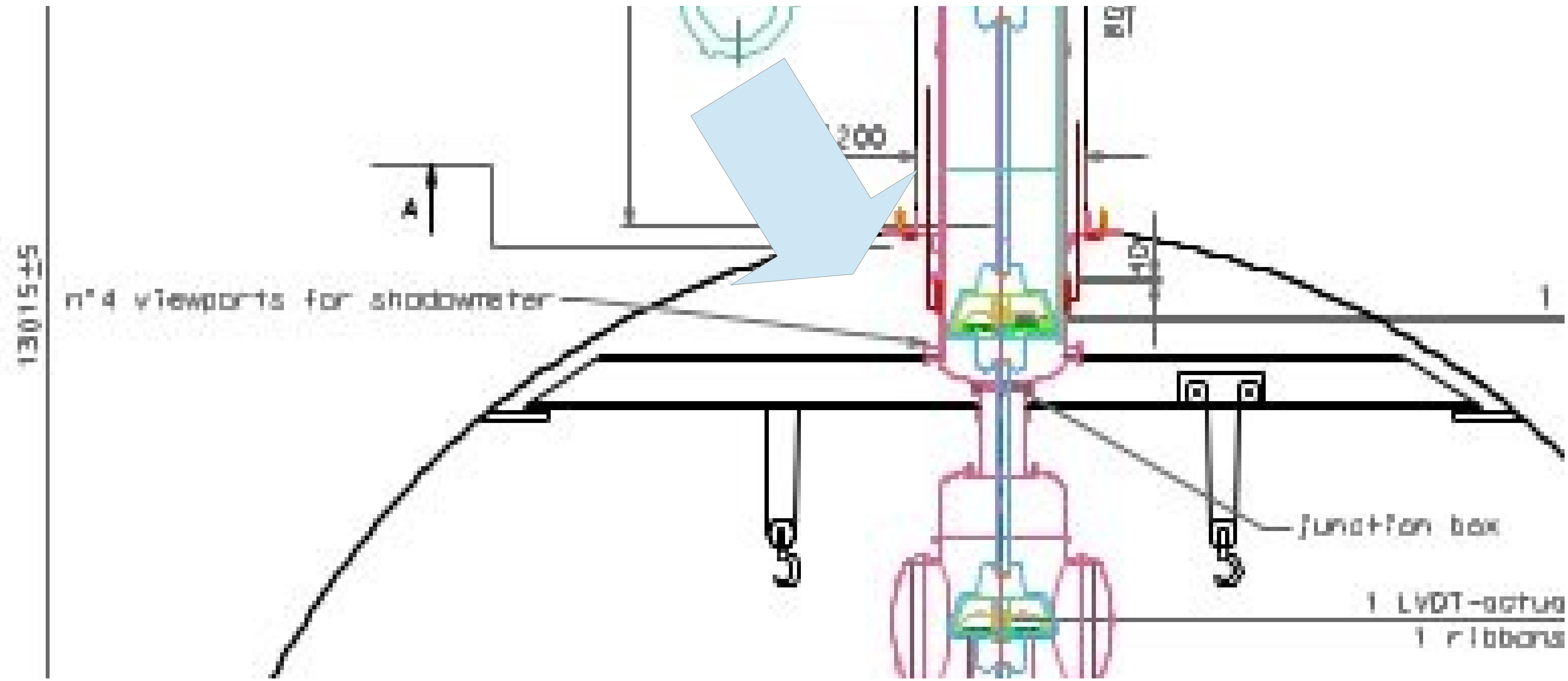
Improved sensitivity

RSS values can be **feed to other on-line detectors** for real-time analysis, error reduction and improved sensitivity.



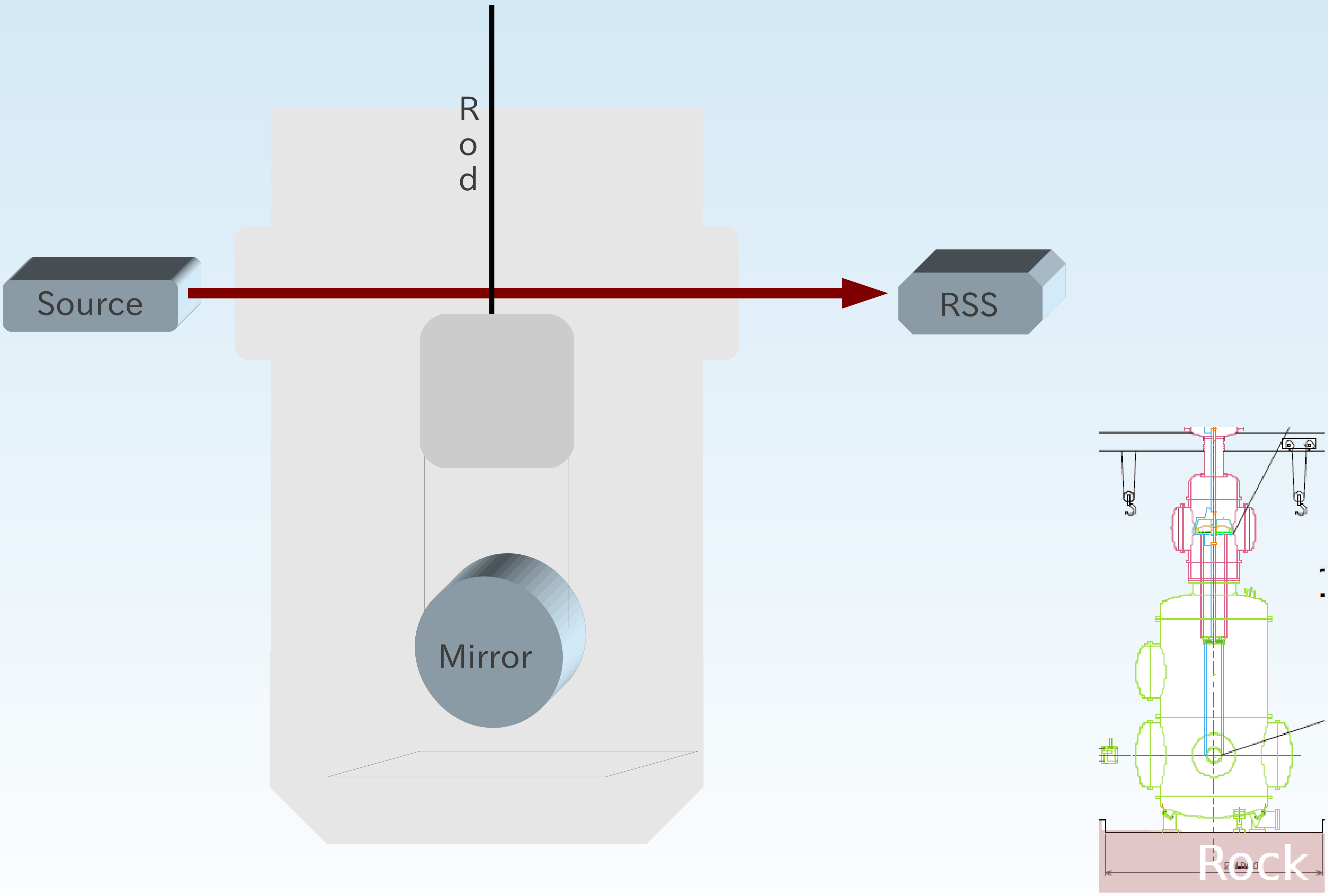
N°4 towers type A

	added note	14-09-12
	added water conditioning	07-07-11
	new version	02-05-11
ref.	note	date
	modifications	
ref. draw.	denomination	



13015±5
n°4 viewports for shadowmeter
A
200
80
15
1
junction box
1 LVDT-actua
1 ribbons

The Remote Shadow minimal sketch



Design goals:

The shadowmeters, two for each test mass, will be located on the roof of the experimental halls, rigidly anchored to the ceiling rock, and will measure the longitudinal and transversal positioning of the suspension wire descending from the higher tunnel, with precision better than 10nm.

The LVDT of the inverted pendulum are sensitive to **both** the horizontal motion and tilt induced by the micro-seismic peak or other seismic activity. The shadowmeter and LVDT differential signal is sensitive **only to the tilt** of the rock, while the LVDT and shadowmeter common signal is sensitive to the horizontal motion of the rock

Geophysical interesting signals

Complement other KAGRA sensors

Design issues:

What light source ?

Stability

λ

Total internal reflection

Absorbency

Radiation pressure

cavity modes

Thermal effects

Plasma resonance

Coherent light?

Design issues:

What detection geometry ?

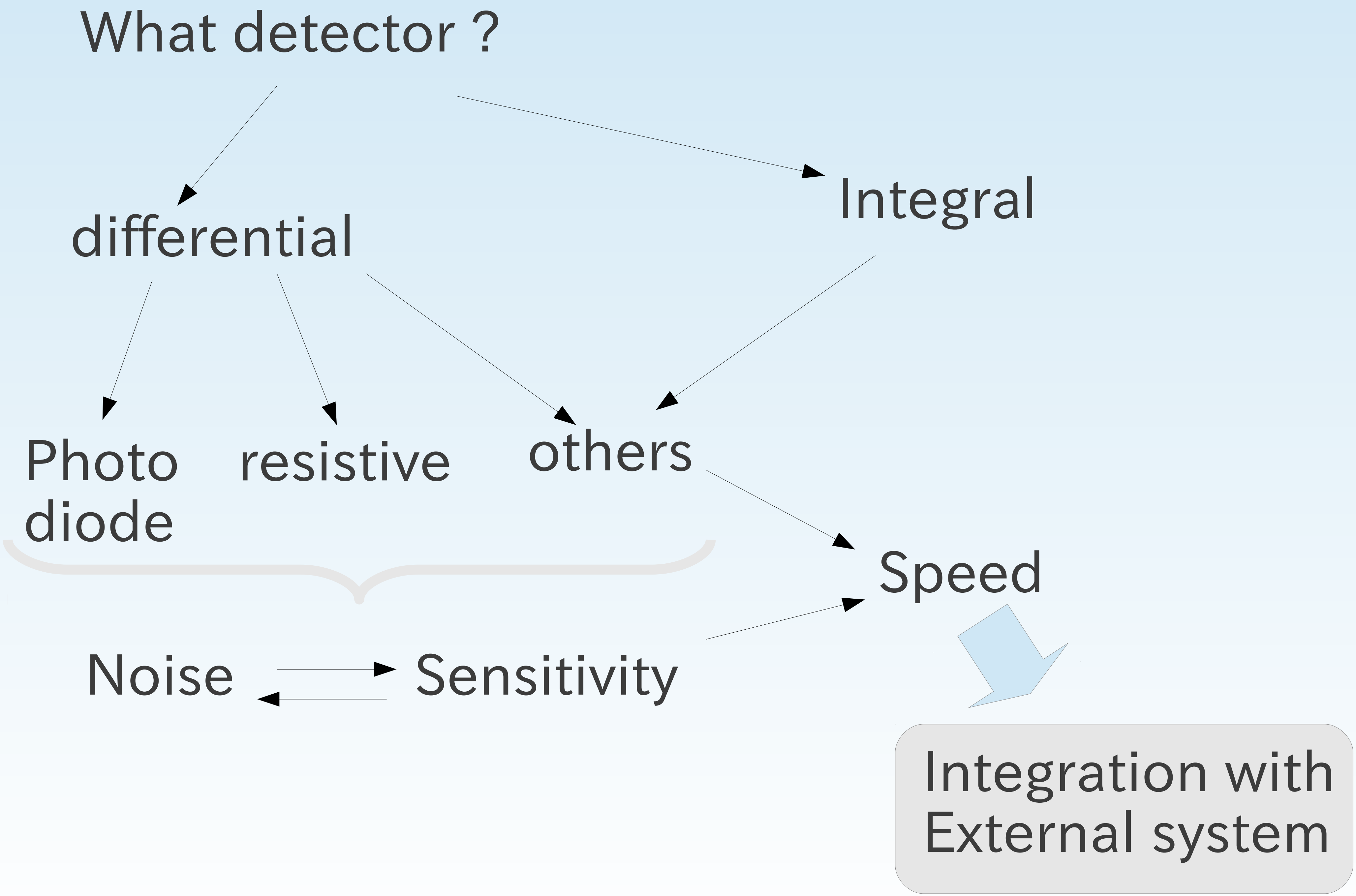
Sensitivity

Passive amplification
(Multiple reflections)

Noise

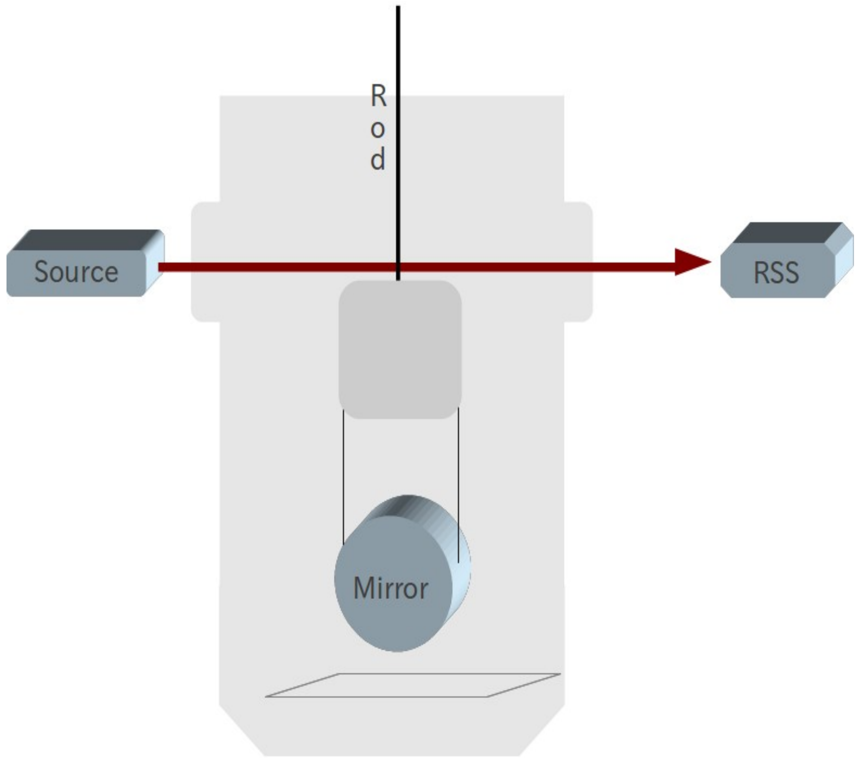
Fancy
structures

Design issues:



Optimization issues:

- laser stability
- optimal lambda
- radiation pressure
- detector noise
- thermal coupling
- minimal displacement
- data compatibility



The team:

R. Micheletto

K. Kuroda

R. De Salvo

W. Chonmeng

(undergraduate)

T. Akutsu